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VITA-LIFE 400 G COATED FLEXIBLE CONDUIT EXPOSURE TO FLOWING TAP WATER

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Ground water entering and flowing through steel pipe conduits and flexible steel conduit joints could cause reduced service life because of corrosion. Corrosion could result in increase of electrical resistance at joints and lead to eventual perforation. These effects could reduce the protection against EMP and lightning. The external surfaces of the flexible steel connectors employed are coated with plastisol; internal surfaces are not coated. The piping, except where threaded, is galvanized

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20. overall. The wall thickness of the connector is approximately 1/7 of that of the pipe (0.031 inch for four inch diameter; 0.022 inch for two inch diameter); hence are more prone to earlier failure.

A proprietary petroleum base grease, containing several percent silica-gel (thickening agent) and several percent of barium petroleum sulfonate (water displacing and corrosion inhibiting agent) has been employed as a protective coating on internal surfaces of the flexible connectors. This report describes an evaluation of the compound applied to a four inch diameter flexible connector which was subjected to flowing tap water. This report also includes an evaluation of the compound applied to mild steel coupons which were immersed in quiescent tap water.

That pitting corrosion and eventual perforation of the coated flexible connector does occur along the water-air interface line is demonstrated, although other areas remain virtually intact. With coated mild steel coupons in quiescent tap water some uniform corrosion without pitting occurs, but this is minor compared to the effect on bare steel specimens.

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INTRODUCTION

As a part of its assigned scope of work on Deterioration Prevention of the Safeguard Missile System, this laboratory was requested by SAFSCOM to investigate the corrosion prevention qualities of a specific proprietary grease coating compound which had been applied to internal surfaces of flexible steel conduit connectors.

The flexible connectors are integral with buried steel pipe conduits, which encase power and communication cables of the Safeguard Site installations, North Dakota. The conduits extend electromagnetic, radio frequency interference and lightning shielding[1].

It had been learned[2] that the presence of discontinuities in the conduits, whether caused by loose connections or by perforations which might result from corrosion over a period of time, could detrimentally affect or compromise the reliability of conduit shielding. Further, it had been reported[1] that water had entered some of the conduits, from some defect in the continuity or jointing, and it had been reported also that water entering the conduit could result in corrosion of the conduit, hence reducing the service life of the system[3]. Corrosion damage to the flexible connector would occur first. The wall thickness of the flexible connector, is approximately 0.031 inch for the four inch diameter size; and 0.022 inch for the two inch size. Although the conduit system is under cathodic protection, only the exterior surfaces, which are in direct contact with the soil, are protected; whereas the interior surfaces are not in the least benefitted.

Information was gathered from a variety of sources to reach an estimate of time of perforation in the event of water leakage into the conduits for uncoated flexible connectors and for the galvanized conduits[4]. Concurrent with this, short term tests of Vita-Life coated 1010 steel coupons were conducted in the laboratory under conditions simulating those observed in the field and under accelerated laboratory testing environments. Results of these tests were reported to SAFSCOM[4].

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[1]Interim Field Conduit Report, U.S. Army Safeguard System Command, 10 May 1973, p.2.

[2]Report of Travel to Bell Telephone Laboratory, Atlanta, GA, Frankford Arsenal, Pitman-Dunn Laboratory, 19 October 1972.

[3]Interim Missile Field Conduit Report, U.S. Army Safeguard Command, 10 May 1973, p.1.

[4]Letter from SMUFA-L3300 to SSC-DES, Subject: SAFSCOM Deterioration Prevention Review - Flexible Conduit Corrosion, 20 February 1973.

Following this, the use of the proprietary compound was recommended for use in the field by the contractor, Bell Telephone Company[5], and was applied to internal surfaces of installed flexible conduits.

A laboratory determination of the effectiveness of the proprietary grease coating compound to prevent corrosion damage of flexible conduit connectors, is presented. This report is interim and offers the findings obtained after one year's testing of a four-inch diameter flexible connector, coated with the compound subject to continuous water flow. The test will continue for an equal period of time.

EXPERIMENTAL APPROACH

A four-inch diameter flexible steel connector, received from the North Dakota Site, was employed in this investigation; its length, 36 inches; its wall thickness, 0.031 inches. The exterior was coated with a thick plastic film; the uncoated interior surface was lightly rusted and soiled. The connector was prepared for testing by cleaning the interior with a stiff bristle cylindrical brush, approximately 3½ inch diameter and five inch length, to remove dirt and loosely adhered rust. This operation was comparable to that employed in the field, except that a mechanically powered, disc, steel brush had been utilized. The end result of the cleaning also were comparable in that lightly adhering rust was easily abraded and removed, whereas some of the hard, thin and tightly adhering rust essentially integral with the steel in certain areas was not effectively removed and was allowed to remain.

Following the brush cleaning of the interior surface, a coating of the proprietary grease coating compound, Vita-Life 400 G* was applied using a cylindrical brush to a thickness of 0.015 to 0.030 inches, by rotating the brush and passing it through the full length of the connector. The compound had been applied externally to cables to serve as a lubricant during pulling operations[5], and it was recommended by Bell Telephone Company, WECO personnel, to be applied on the interior of the flexible connectors as a corrosion preventive coating. This recommendation was later implemented.

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[5] Minutes of Meeting, Huntsville Engineering Division, 14 March 1973, Flexible Conduit Corrosion, North Dakota Site.

*Product of American Oil and Supply Co., NJ. By laboratory analysis, a petroleum base grease, containing several percent of silica thickening agent, and ca. three percent of barium petroleum sufonate, which serves as a water displacing and corrosion inhibiting agent.

The grease-lined connector was tested in the laboratory, by placing it in an essentially horizontal position, inclined about three degrees, and connected at one end to a tap-water tube outlet. Water was introduced at a low flow rate, about 2-2½ gph, so as not to disturb the grease coating by the flow. After three days, the flow was increased to a rate of five gph; this was essentially the rate of flow of water observed issuing several conduits during an inspection tour[6] by SAFSCOM and Frankford Arsenal personnel.

The flexible connector specimen was sectioned longitudinally, providing a lower half, into which the water flowed and an upper half, which was kept in place during the test, to provide a cover and to retain humid conditions inside the specimen during the test, (Figure 1).

At six months' exposure, a portion of the lower half, approximately eight inches in length (ca. one-quarter length) was cut from the outlet end. The Vita-Life coating was removed in trichloroethylene; the external plastic coating was removed by placing the specimen, inverted position, on a hot plate to soften the adhesive and resin for easier stripping. Visual and microscopic examinations of the specimen were performed, and as warranted, photographs of defects were taken.

After twelve months' exposure, the above process was repeated on another quarter-portion of the connector, also about eight inches in length.

In this test, the internal area of the flexible connector in actual contact with flowing water is about one-eighth the total.

Concurrent with the flowing-water exposure test, static-water tests were conducted in which 1010 steel panel specimens, 1 x 2 x 0.032 inch, were used; some were cleaned only, others were coated with Vita-Life 400 G to two thicknesses, i.e., ca. 0.001 or 0.010 inch. Replicates of each of these were immersed in tap water. Dripping of water into the test containers was allowed only to that extent to replace water loss from evaporation. Visual and microscopic examinations were made after three months' and one-year exposure intervals.

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[6] Report of Trip to Nekoma and Langdon, North Dakota, Frankford Arsenal, Pitman-Dunn Laboratory, 26 April 1973.

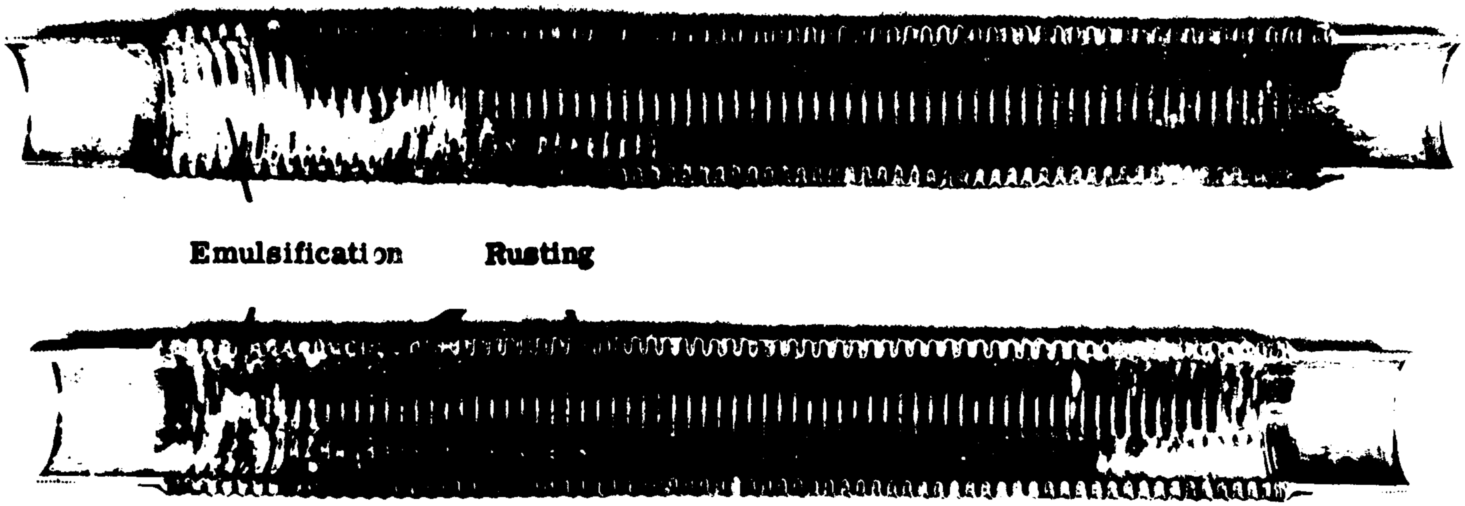

Figure 1. Fcur Inch Flexible Conduit - Three Months

RESULTS AND DISCUSSION

During the first three days the flexible connector was subjected to flowing water (rate 2.5 gph), some whitening of the Vita-Life coating, caused by adsorption of water and emulsification, developed at the waterline, but no rusting of the conduit had occurred. But after a total period of three weeks in contact with flowing water (ca. 5 gph), partial loosening detachment of emulsified material had been noted to occur at the water-conduit interface. Rust spots, not too heavily developed, were apparent at many points along the waterline, but no rusting was observed on surfaces immediately adjacent to, above or below the waterline. Otherwise the Vita-Life coating had not altered in appearance from that when first applied[7].

At the end of three months, it was noted that the emulsified coating had been removed partially by the flowing water, and that the rusting had progressed along the waterline the entire length of the test conduit[8].

The examination of the removed portion of conduit, at the six-month period, after removal of the coatings and cleaning away the rust accumulations, revealed pitting type corrosion, with a narrow band, approximately one inch width, along the wall, paralleling the air-water interface line. One pit resulting in perforation of the conduit section was approximately 1/16 inch in diameter. Several pits of different depths and extensiveness and up to about 1/16 inch diameter, were apparent; the depths were up to 10 mils, representing a penetration of about one-third the wall thickness. Broader width and shallower pitting attack also was evident[9]. These conditions are illustrated in Figure 2.

On the completion of one year's exposure of the conduit to flowing water, the second one-quarter portion of the conduit revealed a total of seven through-wall perforations. The extent and distribution of these is shown in Figure 3. These perforations resulting from crevice corrosion attack ranged in average diameter from 1/32 to 3/16 inch. Other distributed pits, varying in average width and depth, penetrated about half the wall thickness. These primarily occurred in the water-

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[7]Interim Report, Water Immersion Testing of Vita-Life 400 G, Coated Steel, Frankford Arsenal, PDM-A, 19 June 1973.

[8]Interim Report, Water Immersion Testing of Vita-Life 400 G, Coated Steel, Frankford Arsenal, PDM-A, 1 November 1973.

[9]Interim Report, Water Immersion Testing of Vita-Life 400 G, Coated Steel, Frankford Arsenal, PDM-A, 23 January 1974.

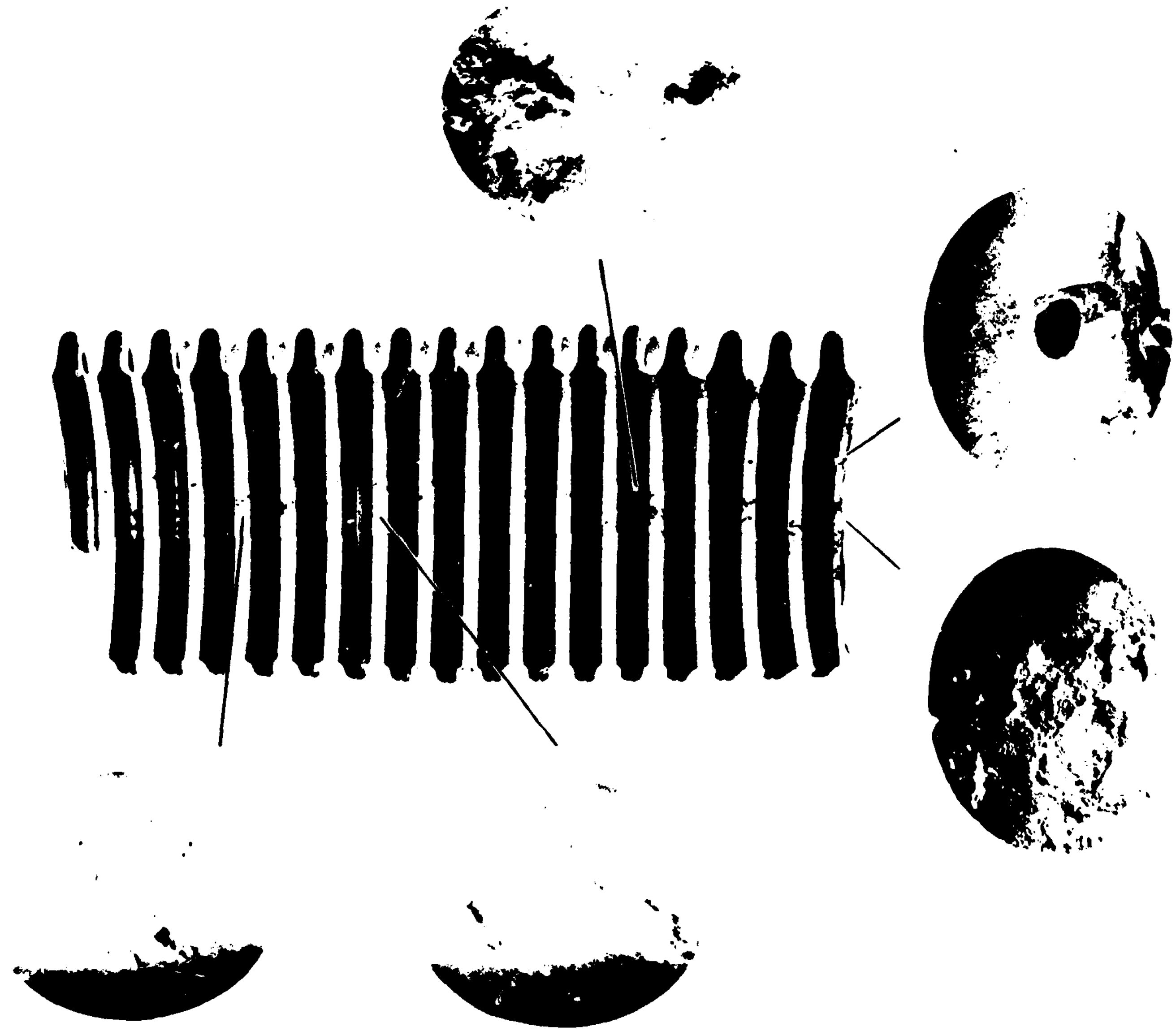

Figure 2. Six Months Exposure

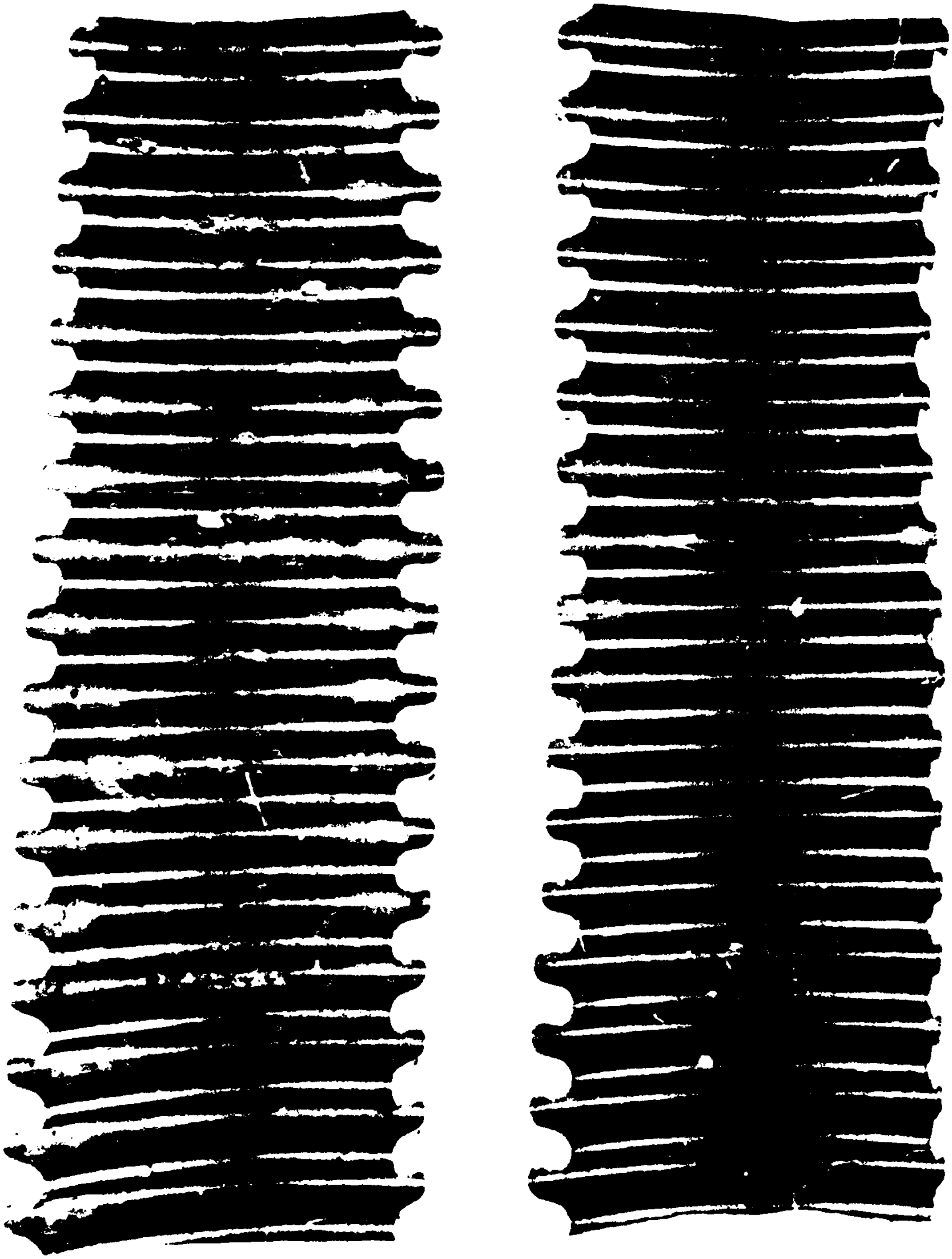

Figure 3. Twelve Months Exposure

air interface region of the conduit. Attack of the pitting type was found also on surfaces still bearing the grease coating, primarily at the waterline and in some areas slightly away from that line.

Coated surfaces of the conduit connector which were not in direct contact with the flowing water were essentially intact after one year, although all such coated surfaces were exposed throughout the test to the high humidity environment prevailing above the water. Some sagging of the coating away from the upper surfaces, had occurred, however a thin film of the compound was retained on the topmost surfaces, causing gradiently heavier coating on successively lower surface points. Yet, the coating on some of the topmost surfaces appeared not to have undergone any significant thinning. It was noted at the one-year period that the Vita-Life coating not in contact with the flowing water had darkened and stiffened perceptibly; nonetheless, these changes in no way compromised the protection of the conduit directly under the coating in these areas.

Uncoated, bare steel, panel specimens immersed in quiescent tap water rusted superficially within one hour. Panels with a 0.001 inch thick coating of Vita-Life 400 G, exposed 17 hours to the same medium developed three small rust spots, ca. 1/16 inch diameter. Other panels with a 0.010 inch thick coating of Vita-Life revealed no evidence of rust under identical conditions of exposure. All specimens in this test were inclined at an angle of approximately 90 degrees from horizontal during the immersion test. The thicker (0.010) coating sagged appreciably within the 17 hour period, but the residual film thickness at the upper level apparently stabilized at about 0.002 inch thickness[7]. At three months' exposure, a few replicate specimens were decoated, rust removed and weight losses determined. The uncoated, bare control specimens lost approximately 4.6 percent of original weight; the 0.001 inch thickness film coated specimen, approximately 0.4 percent; the 0.010 inch thickness film coated specimen, approximately 0.3 percent[8].

Based on visual indications and on weight loss determinations, the Vita-Life coating compound has been found to retard the initiation and progress of uniform corrosion. Furthermore the thicker, 10 mil coating affords longer retardation than does the thinner one mil coating.

After 12 months of immersion, specimens were cleaned and weight losses obtained. Uncoated specimens lost approximately 15.5 percent of

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[7]Interim Report, Water Immersion Testing of Vita-Life 400 G, Coated Steel, Frankford Arsenal, PDM-A, 19 June 1973.

[8]Interim Report, Water Immersion Testing of Vita-Life 400 G, Coated Steel, Frankford Arsenal, PDM-A, 1 November 1973.

original weight; the one mil coated specimens, approximately 1.7 percent and the 10 mil coated specimens approximately 0.8 percent. No perforations nor pitting was observed as in the case of the flexible conduit exposed to flowing tap water.

CONCLUSIONS

The Vita-Life 400 G compound does not prevent corrosion of steel flexible conduit exposed to flowing (5 gph) tap water. Emulsification of the Vita-Life and removal of the Vita-Life by flowing water occurs with resultant corrosion of steel. It is expected that soil water leaking into flexible conduits at North Dakota sites would also result in corrosion of the conduit. Water flow and flow rates are determining factors.

Perforations up to 3/16 inch diameter, through the conduit wall, due to corrosion of Vita-Life coated flexible conduit (1/32 inch steel wall thickness) occurs in less than one year when exposed to tap water flowing at 5 gph. Perforations and pitting in line with the direction of water flow and occur at the water-air interface. Continued exposure beyond one year can be expected to result in increased attack, both in quantity and size of perforations and pits.

The Vita-Life 400 G compound is more effective in retarding the corrosion of steel in "standing" water and retards the corrosion of steel exposed to a humid environment in the vicinity of flowing tap water.

RECOMMENDATIONS

Ideally, preventing entrance of ground water into the conduits would virtually eliminate the problem of corrosion. But it is recognized that this is not a plausible approach at this stage. Consequently the following alternative is offered:

The use of a sprayable liquid water displacing and corrosion inhibiting compound on installed conduit on a periodic basis is also recommended.

REFERENCES

1. Interim Field Conduit Report, U.S. Army Safeguard System Command, 10 May 1973, p.2.

2. Report of Travel to Bell Telephone Laboratory, Atlant , GA, Frankford Arsenal, Pitman-Dunn Laboratory, 19 October 1972.

3. Interim Missile Field Conduit Report, U.S. Army Safeguard Command, 10 May 1973, p.1.

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9. Interim Report, Water Immersion Testing of Vita-Life 400 G, Coated Steel, Frankford Arsenal, PDM-A, 23 January 1974.